ANNEX I

Methodology for Estimating Emissions from International Bunker Fuels used by the U.S. Military

Bunker fuel emissions estimates for the Department of Defense (DoD) were developed using data primarily generated by the Defense Energy Support Center for aviation and naval fuels (DESC 2001). The Defense Energy Support Center (DESC) of the Defense Logistics Agency (DLA) prepared a special report based on data in the Defense Fuels Automated Management System (DFAMS). DFAMS contains data for 1995 through 2000, but the data set was not complete for years prior to 1995. Fuel quantities for 1990 to 1994 were estimated based on a back-calculation of the 1995 DFAMS values using DLA aviation and marine fuel procurement data. The back-calculation was refined last year to better account for the jet fuel conversion from JP4 to JP8 that occurred within the DoD between 1992 and 1995. Data for marine fuel consumption in 2000 were obtained from the Naval Operations Navy Strategic Mobility/Combat Logistics Division (N42 2001).

Gasoline and diesel fuel totals presented in Table I-1 were estimated using data provided by the military services. The 1991 through 1995 data points were interpolated from the inventory data. The 1997 through 1999 motor gasoline and diesel fuel data were extrapolated from the 1996 inventory data. Growth factors used for other diesel and gasoline were 5.2 percent and -21.1 percent, respectively. Data sets for other diesel and gasoline consumed by the military in 2000 were estimated based on Air Force ground fuels consumption trends. This method produced a result that was more consistent with expected consumption for 2000.

Step 1: Omit Extra-Territorial Fuel Deliveries

Beginning with the complete DFAMS data set for each year, the first step in the development of DoD related emissions from international bunker fuels was to identify data that would be representative of international bunker fuel consumption as that term is defined by decisions of the UNFCCC (i.e., fuel sold to a vessel, aircraft, or installation within the United States or its territories and used in international maritime or aviation transport). Therefore, fuel data were categorized by the location of fuel delivery in order to identify and omit all extra-territorial fuel transactions/deliveries (i.e., sales abroad). Table I-1 displays the fuels that remain at the completion of Step 1, summarized by fuel type.

Step 2: Omit Fuel Transactions Received by Military Services that are not Considered to be International Bunker Fuels

Next, fuel transaction/delivery records were sorted by Military Service. The following assumptions were made regarding bunker fuel use by Service, leaving only the Navy and Air Force as users of military international bunker fuels.

- Only fuel delivered to a ship, aircraft, or installation in the United States can be a potential international bunker fuel. Fuel consumed in international aviation or marine transport should be included in the bunker fuel estimate of the country where the ship or aircraft was fueled. Fuel consumed entirely within a country's borders is not bunker fuel.
- Based on discussions with the Army staff, only an extremely small percentage of Army aviation emissions, and none of its watercraft emissions, qualified as bunker fuel emissions. The magnitude of these emissions was judged to be insignificant when compared to Air Force and Navy emissions. Based on this, Army bunker fuel emissions are assumed to be zero.
- Marine Corps aircraft operating while embarked consume fuel reported as delivered to the Navy. Bunker fuel emissions from embarked Marine Corps aircraft are reported in the Navy bunker fuel estimates. Bunker fuel emissions from other Marine Corps operations and training are assumed to be zero.
- Bunker fuel emissions from other DoD and non-DoD activities (i.e., other federal agencies) that purchase fuel from DESC are assumed to be zero.

Step 3: Omit Land-Based Fuels

Navy and Air Force land-based fuel consumption (i.e., fuel not used by ships or aircraft) were also omitted. The remaining fuels, listed below, were potential military international bunker fuels.

- Marine: naval distillate fuel (F76), marine gas oil (MGO), and intermediate fuel oil (IFO).
- Aviation: jet fuels (JP8, JP5, JP4, JAA, JA1, and JAB).

At the completion of step 3 of the 2000 estimate, it was apparent that the Navy maritime data provided by DESC were abnormal compared to those data for each year from 1995 to 1999. The Navy fuels and logistics office identified a separate data set that was used to compare the DESC 2000 data for Navy maritime fuel consumption. After comparing the 2000 data from DESC to that from the Navy, it was determined that the Navy data (N42 2001) should be used as the source of the 2000 maritime values. However, DoD will continue to investigate the 2000 maritime data from DESC, which Navy fuels experts consider an anomaly.

Step 4: Determine Bunker Fuel Percentages

Next it was necessary to determine what percent of the marine and aviation fuels were used as international bunker fuels. Military aviation bunkers include international operations (i.e., sorties that originate in the United States and terminate in a foreign country), operations conducted from naval vessels at sea, and operations conducted from U.S. installations principally over international water in direct support of military operations at sea (e.g., anti-submarine warfare flights). For the Air Force, a bunker fuel weighted average was calculated based on flying hours by major command. International flights were weighted by an adjustment factor to reflect the fact that they typically last longer than domestic flights. In addition, a fuel use correction factor was used to account for the fact that transport aircraft burn more fuel per hour of flight than most tactical aircraft. The Air Force bunker fuel percentage was determined to be 13.2 percent. This percentage was multiplied by total annual Air Force aviation fuel delivered for U.S. activities, producing an estimate for international bunker fuel consumed by the U.S. Air Force. The naval aviation bunker fuel percentage of total fuel was calculated using flying hour data from *Chief of Naval Operations Flying Hour Projection System Budget Analysis Report for FY 1998* (N45 1998), and estimates of bunker fuel percent of flights provided by the fleet. The naval aviation bunker fuel percentage, determined to be 40.4 percent, was multiplied by total annual Navy aviation fuel delivered for U.S. activities, yielding total Navy aviation bunker fuel consumed.

For marine bunkers, fuels consumed while ships were underway were assumed to be bunker fuels. For 2000, the Navy reported that 79 percent of vessel operations were underway, while the remaining 21 percent of operations occurred in port (i.e., pierside). Therefore, the Navy maritime bunker fuel percentage was determined to be 79 percent for 2000. The percentage of time underway may vary from year-to-year and the 2000 value represents a change from previous years, for which the bunker fuel percentage of 87 percent was applied. Table I-2 and Table I-3 display DoD bunker fuel totals for the Navy and Air Force.

Step 5: Calculate Emissions from Military International Bunker Fuels

Bunker fuel totals were multiplied by appropriate emission factors to determine greenhouse gas emissions (see Table I-4 and Table I-5).

The rows labeled 'U.S. Military' and 'U.S. Military Naval Fuels' within Table 2-43 and Table 2-44 in the Energy Chapter were based on the international bunker fuel totals provided in Table I-2 and Table I-3, below. Total CO_2 emissions from military bunker fuels are presented in Table I-6. Carbon dioxide emissions from aviation bunkers and distillate marine bunkers presented in Table 2-42 are the total of military plus civil aviation and civil marine bunker fuels, respectively. The military component of each total is based on fuels tallied in Table I-2 and Table I-3.

Table I-1: Transportation Fuels from Domestic Fuel Deliveries[a] (Million Gallons)

Vehicle Type/Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Aviation	**4,598.45**	**4,562.84**	**3,734.49**	**3,610.85**	**3,246.23**	**3,099.93**	**2,941.91**	**2,697.28**	**2,764.76**	**2,670.28**	**2,711.16**
JP8	285.75	283.54	234.46	989.38	1,598.07	2,182.80	2,253.15	2,083.64	2,145.89	2,101.52	2,169.42
JP5	1,025.36	1,017.42	832.71	805.14	723.84	691.22	615.83	552.77	515.56	505.50	472.10
Other Jet Fuels	3,287.31	3,261.86	2,667.29	1,816.30	924.30	225.89	72.92	60.86	103.29	63.25	69.65
Aviation Gasoline	0.03	0.03	0.02	0.02	0.02	0.02	0.01	+	0.02	0.01	0.01
Marine	**686.80**	**632.61**	**646.18**	**589.37**	**478.59**	**438.91**	**493.34**	**639.85**	**674.22**	**598.86**	**680.19**
Middle Distillate (MGO)	+	+	+	+	+	+	38.52	47.48	51.14	49.22	97.61
Naval Distillate (F76)	686.80	632.61	646.18	589.37	478.59	438.91	448.96	583.41	608.39	542.94	549.57
Intermediate Fuel Oil (IFO)[b]	+	+	+	+	+	+	5.86	8.95	14.69	6.70	33.01
Other	**717.11**	**590.41**	**491.68**	**415.10**	**356.06**	**310.95**	**276.90**	**251.66**	**233.47**	**220.92**	**201.45**
Diesel	93.04	97.88	102.96	108.31	113.94	119.86	126.09	132.64	139.53	146.78	126.63
Gasoline	624.07	492.53	388.72	306.78	242.12	191.09	150.81	119.02	93.94	74.14	74.81
Total (Including Bunkers)	**6,002.37**	**5,785.85**	**4,872.34**	**4,615.32**	**4,080.89**	**3,849.78**	**3,712.15**	**3,588.79**	**3,672.45**	**3,490.06**	**3,592.80**

Note: Totals may not sum due to independent rounding.

[a] Includes fuel consumption in United States and U.S. Territories.

[b] Intermediate fuel oil (IFO 180 and IFO 380) is a blend of distillate and residual fuels. IFO is used by the Military Sealift Command.

+ Does not exceed 0.005 million gallons.

Table I-2: Total U.S. Military Aviation Bunker Fuel (Million Gallons)

Fuel Type/Service	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
JP8	**56.74**	**56.30**	**46.40**	**145.33**	**223.99**	**300.40**	**308.81**	**292.01**	**306.39**	**301.35**	**307.57**
Navy	56.74	56.30	46.08	44.56	40.06	38.25	39.84	46.92	53.81	55.46	53.38
Air Force	+	+	0.32	100.77	183.93	262.15	268.97	245.09	252.59	245.89	254.19
JP5	**370.53**	**367.66**	**300.92**	**290.95**	**261.57**	**249.78**	**219.40**	**194.16**	**184.38**	**175.37**	**160.35**
Navy	365.29	362.46	296.66	286.83	257.87	246.25	216.09	191.15	181.36	170.59	155.60
Air Force	5.25	5.21	4.26	4.12	3.70	3.54	3.31	3.01	3.02	4.77	4.74
JP4	**420.77**	**417.52**	**341.40**	**229.64**	**113.11**	**21.50**	**1.05**	**0.05**	**0.03**	**0.02**	**0.01**
Navy	0.02	0.02	0.02	0.02	0.01	0.01	+	+	+	+	+
Air Force	420.75	417.50	341.39	229.62	113.10	21.49	1.05	0.05	0.03	0.02	0.01
JAA	**13.70**	**13.60**	**11.13**	**10.76**	**9.67**	**9.24**	**10.27**	**9.42**	**10.84**	**10.78**	**12.46**
Navy	8.45	8.39	6.86	6.64	5.97	5.70	6.58	5.88	6.63	6.32	7.95
Air Force	5.25	5.21	4.27	4.12	3.71	3.54	3.69	3.54	4.21	4.47	4.51
JA1	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**0.01**	**+**	**0.03**
Navy	+	+	+	+	+	+	+	+	+	+	0.02
Air Force	+	+	+	+	+	+	+	+	0.01	+	0.01
JAB	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Navy	+	+	+	+	+	+	+	+	+	+	+
Air Force	+	+	+	+	+	+	+	+	+	+	+
Navy Subtotal	**430.50**	**427.17**	**349.62**	**338.04**	**303.91**	**290.21**	**262.51**	**243.95**	**241.80**	**232.37**	**216.90**
Air Force Subtotal	**431.25**	**427.91**	**350.23**	**338.63**	**304.44**	**290.72**	**277.02**	**251.70**	**259.86**	**255.14**	**263.50**
Total	**861.75**	**855.08**	**699.85**	**676.68**	**608.35**	**580.93**	**539.53**	**495.65**	**501.66**	**487.52**	**480.40**

+ Does not exceed 0.005 million gallons.

Note: Totals may not sum due to independent rounding.

Table I-3: Total U.S. DoD Maritime Bunker Fuel (Million Gallons)

Marine Distillates	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Navy - MGO	+	+	+	+	+	+	30.34	35.57	31.88	39.74	77.11
Navy - F76	522.37	481.15	491.47	448.27	364.01	333.82	331.88	441.65	474.23	465.97	434.16
Navy - IFO	+	+	+	+	+	+	4.63	7.07	11.61	5.29	26.08
Total	**522.37**	**481.15**	**491.47**	**448.27**	**364.01**	**333.82**	**366.85**	**484.29**	**517.72**	**511.00**	**537.35**

+ Does not exceed 0.005 million gallons.

Note: Totals may not sum due to independent rounding.

Table I-4: Aviation and Marine Carbon Contents (Tg Carbon/QBtu) and Fraction Oxidized

Mode (Fuel)	Carbon Content Coefficient	Fraction Oxidized
Aviation (Jet Fuel)	variable	0.99
Marine (Distillate)	19.95	0.99

Table I-5: Annual Variable Carbon Content Coefficient for Jet Fuel (Tg Carbon/QBtu)

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Jet Fuel	19.40	19.40	19.39	19.37	19.35	19.34	19.33	19.33	19.33	19.33	19.33

Table I-6: Total U.S. DoD CO_2 Emissions from Bunker Fuels (Tg CO_2 Eq.)

Mode	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Aviation	8.2	8.1	6.6	6.4	5.8	5.6	5.2	4.8	4.8	4.7	4.6
Marine	5.2	4.8	4.9	4.5	3.7	3.4	3.7	4.9	5.2	5.1	5.4
Total	**13.4**	**12.9**	**11.6**	**10.9**	**9.5**	**8.9**	**8.9**	**9.6**	**10.0**	**9.8**	**10.0**

Note: Totals may not sum due to independent rounding.